22

L2: Entry 2 of 3 File: USPT Apr 17, 2001

DOCUMENT-IDENTIFIER: US 6219609 B1
TITLE: Vehicle dynamic control system

Abstract Text (1):
The present invention provides a vehicle dynamic control system which alters characteristics of respective vehicle movement controllers so that they can function properly against coming and foreseeable running conditions and current running conditions, recognizing beforehand details of an emerging curve on the road to be traveled. The system comprises a vehicle movement control alterant and at least one among vehicle movement controllers, i.e., a brake controller, a left/right wheel differential limiter controller and power distribution controller. When the vehicle is approaching the curve, the vehicle movement control alterant alters characteristics of a braking controller, the left/right wheel differential limiter controller and the power distribution controller to those favorable to turning for driving through a curve appropriately. When the vehicle is approaching the curve end, the alternate alters characteristics of the left/right differential controller to those favorable to stabilizing running so that the vehicle can pass the curve end and go into straight road appropriately.

Brief Summary Text (13):
Furthermore, the present invention provides a vehicle dynamic control system aforementioned, wherein the vehicle movement controlling means is the left/right-wheel-differential limiter controller, and changing of the characteristic of the vehicle movement controlling means to that favorable to turning is done by weakening the limitation of the differential of the left and right wheels and vice versa, i.e., changing the characteristic of the vehicle movement controlling means to that favorable to stabilizing the vehicle's posture is done by strengthening the limitation of the differential of the left and right wheels.

Brief Summary Text (14):
Furthermore, the present invention provides a vehicle dynamic control system aforementioned, wherein the vehicle movement controlling means is the power distribution controller for controlling the differential limitation of a center differential, and changing of the characteristic of the vehicle movement controlling means to that favorable to turning is performed by controlling the limitation of the differential to an uneven torque distribution to the front and rear wheels, either the front bigger or the front smaller, while changing the characteristic of the vehicle movement controlling means to that favorable to stabilizing vehicle posture is done by controlling the limitation of the differential to even torque distribution.

Detailed Description Text (35):
In the steering control mode, the differential limiting torque is reduced from that specified for the normal control mode depending on the rotational ratio (NR/NF) of the front and rear wheels in a specified vehicle speed range, in order to improve the feeling of steering in a low speed range. NR is the number of rear wheel rotations and NF is the number of front wheel rotations.

Detailed Description Text (38):
The left/right wheel differential limiter control 70 controls the hydraulic multi-

plate clutch 33. The rotational speed difference of the 2 rear wheels is calculated from the number of rotations of the rear left and right wheels. When the rear wheel rotation speed difference is bigger than a predetermined value, it is judged that the rear wheels are slipping. When the rear wheel rotation speed difference is smaller than a predetermined value, it is judged that the rear wheels are not slipping.

Detailed Description Text (63):
wherein G1 and G2 are gains (e.g., 0.05 and 0.15 respectively), Iz is yaw inertia moment oh the vehicle, df is the front tread and dr is the rear tread. In the formula (10), G1 is the first large gain and d.DELTA..gamma..times.Iz/(df/2) is a part showing the first theoretical braking force for the front wheels. In the formula (11), G1.times.G2 is the first small gain and d.DELTA..gamma..times.Iz/(dr/2) is a part showing the first theoretical braking force for the rear wheels. In order to prevent losing stability caused by side slips occurring at a rear wheel or to prevent a feeling of unstableness given by unexpectedly strong turning moment occurring when the rear wheels are braked, especially on a low friction road, the first rear wheel aimed pressure BF1r is made smaller by multiplying the first theoretical braking force for the rear wheels by the first small gain.

Detailed Description Text (172):
The brake controller 80 selects the rear inside wheel for correcting an under steering characteristic while turning, or the front outside wheel for correcting an over steering characteristic while turning, and sends a control signal to the brake actuator 25 so that the aimed braking force is applied to the selected wheel. This is carried out, while comparing the yaw rate deflection .DELTA..gamma. with the threshold .epsilon..DELTA., when the yaw rate deflection .DELTA..gamma. comes from inside of the insensitivity band to the outside, i.e., to the control area.

CLAIMS:

6. The dynamic control system according to claim 5, wherein the vehicle dynamic characteristic changing means includes means for reducing the differential limiting force of the wheel differential controlling means so as to improve turning performance.

Previous Doc Next Doc Go to Doc#

L2: Entry 1 of 3 File: USPT Sep 3, 2002

DOCUMENT-IDENTIFIER: US 6446005 B1
TITLE: Magnetic wheel sensor for vehicle navigation system

Abstract Text (1):
A system is disclosed for determining precise locations of the golf carts on a golf course in real time as the carts are in use during play of the course. Each cart is outfitted with a dead reckoning navigation (DRN) system for determining speed and direction, and a compass for determining heading of the cart during play. With these parameters and a known origin of the cart to which the DRN system has been calibrated, such as location of a tee box, the location of the cart relative to a known feature of the course such as a cup or hazard may be calculated. The DRN system uses a magnetic wheel sensor assembly having a magnetic strip with spaced alternating opposite magnetic poles affixed to the rim of an inside wheel well or mounting fixture therefor of the cart, mounted to confront a Hall effect sensor. During rotation of the wheel and the strip when the cart is moving, the sensor detects passage of the alternating poles, to measure speed and forward or backward direction of the cart. A compass determines heading of the cart. The DRN system allows operation on courses where GPS-based systems cannot maintain LOS, and is periodically calibrated by a known signal, such as a DGPS signal.

Brief Summary Text (24):
Mechanical issues addressed in the implementation of sensors of the ACUTRAK system on a golf cart include (1) selection and mounting of the wheel sensor used for measuring distance traversed by the cart, and (2) selection and mounting of the electronic compass used for measuring bearing (direction, relative to a reference direction, typically true north). It is necessary to determine the most desirable or advantageous wheel for location of the wheel sensor on the golf cart. The rear wheels of the cart undergo slippage during rapid acceleration and braking on wet grass; hence, mounting the sensor on a rear wheel is more likely to result in errors in determination of distance traveled by the cart under those conditions. On the other hand, since the front wheels of the cart can turn, wheel velocity is computed along the direction that the wheel is pointed rather than the direction the cart frame is pointed. Resulting error may be overcome mathematically in navigation software for the ACUTRAK system, as described in the '962 application.

Brief Summary Text (25):
Selection of a proper sensor for detecting wheel rotation involves several factors. Hall effect sensors detect the presence of magnetic fields and are sufficiently rugged to withstand outdoor extremes of temperature, moisture, and soil contamination, with a limited capability to sense fine movements of the wheel as it rotates, for higher resolution. Optical sensors possess the capability to sense extremely fine movements, but lack robustness in an outdoor environment, and are more expensive than magnetic sensors.

Brief Summary Text (26):
The ACUTRAK system disclosed in the '962 application employs a dead reckoning system that uses a floated compass in conjunction, in one embodiment, with a wheel sensor mounted on one front wheel, with a special acceleration compensation algorithm referred to therein as "compass tilt estimation" algorithm for the floated compass. It is desirable for wheel rotation resolution to be at least 64

counts per wheel revolution, i.e., to possess the capability to detect at least every 5.625 degrees of revolution. A floated compass has a sensor which is floated in a liquid bath and which uses the Earth's gravity to keep the sensor level with respect to the gravity field, thereby resulting in the compass sensor remaining fixed with respect to the earth's magnetic field. In this way, a floated compass allows accurate measurement of magnetic heading under various adverse conditions--for example, when the golf cart is tilted on a hill.

Brief Summary Text (27):
To overcome potential loss of accuracy arising from response of the floated compass to acceleration of the golf cart (e.g., starting, braking, or turning) such that the sensor is artificially tilted throughout an acceleration event, compensation for compass errors that arise during such an event is achieved in the system of the '962 application by high resolution wheel sensing to at least 64 counts per revolution, and an acceleration compensation algorithm run in the navigation computer to predict the effect of the induced tilt on the compass heading output. With a dual front wheel sensor configuration, even greater resolution is required--minimally about 720 counts per revolution (equating to a capability to detect at least every 0.5 degrees of revolution), because mathematical algorithms for such a configuration are highly sensitive to wheel quantization for accurate dead reckoning performance.

Brief Summary Text (28):
In an embodiment of the '962 application system, a wheel sensor constituting a standard optical encoder is employed, with modifications designed for survival of the sensor in the hostile outdoor environment of the golf course. The modifications include encapsulating the case of the sensor in an epoxy compound to seal it against penetration and fouling by water or soil, and using a sealed bearing on the encoder shaft for the same purpose. The wheel sensor has an effective resolution of 1024 counts per revolution, and is projected to be capable of 200 million rotations without failure. In practice, however, "sealed" bearings are something of a misnomer in that they do not filly inhibit fouling in a hostile environment. Hence, the sensor and the accuracy of the system must be subjected to frequent inspection. Servicing or replacement of the wheel sensor must be undertaken in aggravated cases. It would be desirable to provide an improved wheel sensor system, and it is a principal objective of the present invention to do so.

Brief Summary Text (30):
According to the present invention, an ACUTRAK system is implemented in part using a wheel sensor in the form of Hall effect magnetic rotation system. A floated compass is used in conjunction with the wheel sensor for accurate measurement of the rotation and the direction of rotation of the wheel. The sensor element is attached to a mounting bracket, and a magnetic strip is attached to a mounting frame. The data collected is used to measure distance traveled and cart velocity, as well as detection of vehicle motion, among other things. Unlike other types of wheel sensors, the magnetic wheel sensor is capable of providing rotation measurements in electrically and magnetically noisy environments. This is achieved in part by making the housing for the Hall effect sensors electrically conductive and grounding it to the internal sensor ground. Additionally, the Hall effect sensor assembly is electrically insulated from the chassis of the golf cart. The system generates its data output without any physical interfaces, which effectively eliminates sources of degradation attributable to friction. Moreover, the magnetic wheel sensor can be fully sealed by electrically connecting the sensor integrated circuit (IC) to a printed circuit board, inserting the board into the housing, and then potting the board and the sensor IC assembled thereon completely in place with epoxy, for example, to avoid damage from outside contaminants. Additional advantages of the magnetic wheel sensor are its relative simplicity of assembly, installation, and inspection.

Brief Summary Text (31):

According to the invention, then, apparatus is provided for installation on a golf cart to enable calculation of the distance from the cart to a golf cup, a hazard, or other feature of a hole of a golf course which has been surveyed so that the location of such feature is known, from which to make a close approximation of the distance to such feature from a golf ball in a lie proximate to the cart. The apparatus includes a dead reckoning (DR) wheel sensor arrangement for determining speed and direction (forward/reverse) of the cart relative to a tee box of the hole as a known point of origin to which the DR assembly has been calibrated. The arrangement includes a magnetic strip with a plurality of alternating magnetic poles impressed across the strip, which is attached to the rim of a mounting fixture inside the wheel well of the cart. The Hall effect sensor assembly is affixed to the axle of the wheel for detecting passage of the alternating magnetic poles on the strip during rotation of the wheel. A floated compass is attached to the cart, preferably substantially directly above this wheel, to determine the cart heading. Knowing the parameters of speed, forward/reverse direction, and heading of the cart at any given instant relative to the origin enables calculation of real-time distance from the cart to the known location of a feature of interest of the hole being played with the cart.

Drawing Description Text (11):
FIG. 9 is a simplified top view of a DR navigation system-equipped golf cart showing the front wheels angled in a turn, useful to explain the embodiment of FIG. 8; and

Detailed Description Text (3):
As is known, "dead reckoning navigation" is initialized with a starting position, velocity, and, in some instances, attitude of the host vehicle, and keeps track of changes in movement, distance and direction of the vehicle from the starting point. The present invention provides an improved wheel rotation sensor as a key component of a cost effective dead reckoning navigation system for use on a golf course. The sensor enables measurement of distance by reference to the number of rotations of the wheel from the starting point, while the direction of travel, which need not and typically would not be a straight line from one point of interest to another, is determined in the horizontal plane by means of an inexpensive compass sensor, for example.

Detailed Description Text (6):
The preferred approach in the DR system for golf course applications uses a single front wheel sensor to measure distance and a floated sensor compass for measuring direction. Only speed and direction in the horizontal plane are needed. Alternatives include use of (i) dual front wheel sensors detecting the wheel rotation for measuring distance, and measuring the difference between the wheel rotations for determining the angular rate; or (ii) a fixed sensor compass for detecting direction, a terrain database for slope locations, and a single front wheel sensor for measuring distance. Dual front wheel sensors are viable but have the disadvantage that turning the front wheels of the cart causes them to be misaligned with the longitudinal axis of the cart Alternative (ii) is also viable, but requires a sophisticated terrain database to determine the severity of the slope at any particular location on the golf course.

Detailed Description Text (9):
In conjunction with the preferred embodiment of a wheel sensor mounted on one front wheel, the floated compass employs a compass tilt estimation algorithm described in detail in the '962 application. The floated compass uses a sensor floated in a liquid bath so that the sensor remains fixed with respect to the earth's gravity and magnetic field, whereby to enable accurate measurement of heading even when the golf cart is tilted on a hill. It is desirable that wheel rotation resolution be at least 64 counts per wheel revolution, to detect at least every 5.625 degrees of revolution. The floated compass sensor is artificially tilted during cart acceleration in starting, braking, or turning, producing errors which are

compensated by (i) the high resolution wheel sensing and (ii) the compass tilt estimation algorithm.

Detailed Description Text (10):
Dual front wheel sensors require greater resolution, on the order of minimum resolution of 720 counts per revolution which equates to detection of every 0.5 degrees of revolution. This is because the mathematical algorithms for a dual front wheel application are extremely sensitive to wheel quantization for accurate dead reckoning performance.

Detailed Description Text (11):
In a preferred embodiment of a wheel sensor assembly 24 of the present invention, shown in exploded view in FIG. 3 and in assembled view in FIG. 4, the magnetic wheel rotation system includes a sensor 25, a sensor mounting bracket 26, a magnetic strip 28, and a magnet mounting fixture 29. As further shown in the more detailed sectioned side view of FIG. 5A, the sensor 25 includes a dual element Hall effect sensor device 30, which, in the preferred embodiment is a Hall effect speed/direction sensor (e.g., part number A3421, available from Allegro Microsystems, Inc. of Worcester, Mass.). The Hall effect sensor device 30 is soldered to a printed wiring board or printed circuit board (PCB) 32, and the PCB with attached sensor is then inserted into a metallic (electrically conductive) cylindrical housing or cylinder 31 (see, also, FIG. 5B). As shown in FIG. 5A, also provided are a grounding lug 33 from a short wire 34 associated with a four conductor shielded cable 35 (FIG. 5C), a connector 36, and connector pins 37, for purposes to be described presently.

Detailed Description Text (13):
With continued reference to FIG. 5A, short wire 34 and grounding lug 33 crimped thereto are fastened to housing cylinder 31 by a corrosive-resistant screw 41, to assure that the cylinder shares the same electrical ground with the Hall effect sensors 38, 39. The use of an electrically conductive housing which is grounded in this manner serves to shield the device against electrical and magnetic noise present in the environment in which the housing is located, and which would otherwise preclude proper operation and functioning of the Hall effect sensor. The PCB 32 is dimensioned and configured to slide into the metal cylinder 31 so as to position the attached sensor device a minimum distance d (typically, 0.020 inch) from one end of the cylinder, facing the magnetic strip 28 (FIGS. 3 and 4) when the wheel sensor assembly is fully assembled on a front wheel of the cart. This configuration helps to maximize the performance of the magnetic wheel rotation system of wheel sensor assembly 24.

Detailed Description Text (17):
Strip 28 is magnetized with north and south poles arranged in an alternating pattern (for example, alternating poles every 1/4 inch for the exemplary length dimension noted above) as viewed from the surface of the magnetic strip confronting an end of Hall effect sensor device 30 when the unit is assembled onto a front wheel of the golf cart. All of the alternating poles are of the same width. Ideally, the magnetic strip has a length such that an integer number of north-south pole pairs is present when it is installed onto the magnet mounting fixture 29. In practice, however, the magnetic strip length--such as that in the above example--may be slightly longer to compensate for contraction of the magnetic material during assembly (90-1/2 poles, rather than 90 poles, in the latter example). This slight additional length will degrade the instantaneous accuracy of the wheel rotation sensor system to a virtually negligible extent. Since there is no contact between elements of sensor device 30 and magnetic strip 28 during relative movement therebetween when the golf cart is in use, the sensor system itself will not suffer degradation or wear as a result of any frictional force, which is a distinct advantage.

Detailed Description Text (18):

The magnet mounting fixture 29 is a somewhat bowl-shaped piece of material intended to mate with the inner portion of the wheel hub 43 and with mounting holes that mate with mounting holes of the hub, so that fixture 29 will accept the wheel mounting lugs or bolts of the vehicle. It is essential that the magnet mounting fixture mounting holes be precisely sized and aligned with those of the vehicle wheel mounting lugs to minimize any variation in the spacing between magnetic strip 28 and sensor device 30 during relative rotation of the two after installation of the wheel sensor assembly on the cart. The magnet mounting fixture is specially constructed to allow the magnetic strip 29 to be attached to its internal surface at the rim portion of the fixture, without the presence of protuberances or unevenness of any other kind. The adhesive used to attach the magnetic strip to the magnet mounting fixture, while not confined to the exemplary Loctite material referred to above, should be selected to avoid any adverse effect from materials or temperatures likely to encountered by the cart during normal use.

Detailed Description Text (20):
It is important to observe that as a result of the design provided by the present invention, the lateral alignment of the sensor to the magnetic strip is not crucial. In practice, the wheel sensor assembly bracket is readily attached to the cart, and the wheel is then bolted on in the usual manner, with little or no need for any further adjustment. As noted earlier herein, while either front wheel may be selected as the one with which the assembly is to cooperate, the left front wheel is preferred, taking into account factors such as the location and added weight of the driver of the cart, the location of the antenna for the GPS system to be used for periodic or sporadic calibration of the DR navigation system, and the proximity to fixed sources of potential electrical or magnetic interference on the cart. As a practical matter, the magnetic wheel sensor assembly 24 is installed on a fully assembled cart by removing the designated front wheel 45 from the hub of the cart 50. Once the wheel is removed, the sensor mounting bracket 26 is readily attached to the front axle 51 (or other suitable fixed part of the structure of the vehicle), so as to finally maintain the relative positions of the sensor device 30 and magnetic strip 28 to permit rotation of the latter about the former when the installation of the entire wheel sensor assembly 24 is completed.

Detailed Description Text (21):
By way of example, as illustrated in FIGS. 3, 4, and 6, the magnet mounting fixture 29 of wheel sensor assembly 24 resides in the wheel hub 43 of the front wheel 45 (e.g., on the left, or driver's, side) from its position on the front axle 51 of the golf cart 50. Mounting bracket 26 is slidably positioned along and above front axle 51 with an adjustable collar clamp 52 about its lower leg for rotational alignment of sensor device 30 with magnetic strip 28, i.e., so that the upper end of the Hall effect sensor device is aligned to directly confront the magnetic strip 28 at all times during rotation of the latter about the former, albeit that the two are maintained at all times in precise spaced-apart relation by the longitudinal alignment of the sensor device. The cable 35 is then routed such that it will not bind or be pinched by any portion of the structure, either while the cart is moving or at a standstill. To that end, as well as to prevent excessive stress or strain on the wire conductor connections of cable 35 to PCB 32 potted within cylinder 31, the cable may be secured to the mounting bracket 26 by a tie-down clamp 58 (FIG. 5). The magnet mounting fixture 29 is slid over the wheel mounting lugs for reinstallation of wheel 45. Upon proper rotational alignment of the sensor device 30 relative to the magnetic strip, the attachment bolts 54 (which have been inserted through respective mating holes in axle bearing mounting flange 56, magnet mounting fixture 29 and wheel hub 43 during the assembly process) are secured by final tightening of nuts 55 thereon, and the collar clamp 52 is tightened to secure the mounting bracket in place in the final assembly. Mounting of the Hall effect sensor device 30 above the axle 51 is preferred because in this location the axle keeps the sensor sheltered from water, mud, soil, rocks, grass, fertilizer, twigs, branches, and other debris that might be encountered as the cart is driven along the course during play. The location of the sensor device 30 inside the wheel well

44 at the rim thereof further protects the sensor. Of course, debris is much less a problem where the cart is used on courses having a "cart path only" rule for driving the golf cart.

Detailed Description Text (25):
The Hall effect sensor device 30 is supplied with power through the sensor cable 35 by means of a power wire and a ground wire among the four conductors. One of the remaining two conductor wires of cable 35 provides an output signal from the sensor device indicative of speed, the speed signal being composed of digital output pulses whose number is proportional to the number of magnetic poles on magnetic strip 28 that pass by the Hall effect sensor device 30 during rotation of the wheel as the cart is driven along the course. The remaining conductor wire of cable 35 provides an output signal from the sensor device indicative of direction (forward movement or backward movement of the cart) as described earlier herein. An alternate approach is to send the outputs of the two Hall effect sensors through these two wires directly to the DRN computer for quadrature decoding.

Detailed Description Text (31):
In the latter path, the output of magnetic wheel sensor 64 is subjected to application of a wheel scale factor error correction Sf.sub.w from the DGPS/DR calibration at 75, to compensate an error that increases with distance traveled over time. The resulting output undergoes processing similar to that provided in the compass sensor path, as described above, so that the pair of outputs related to wheel speed and acceleration are obtained and applied to develop the compass tilt estimation at 68, while the wheel speed factor is also applied to provide steering compensation at 76. Also applied to the latter are the turn rate (rate of change of heading) factor .omega..sub.m and a factor representing the wheel base of the cart, from which speed (velocity) compensation factors V.sub.x and V.sub.y are derived for application to table calculator 74.

Detailed Description Text (34):
FIG. 9 is a simplified top view of golf cart 50 showing the front wheels 45 (left) and 80 (right) angled in a turn and the various angles and dimensions used in calculations. Steering compensation is achieved as follows. The left front wheel is being used for speed determination, and the direction of the front wheels is not aligned with the body frame of cart 50 in a turn. Turned front wheels induce velocity in both the vehicle x and y axes. The steering angle .alpha. is determined from the wheel speed, turn rate, and wheel base. For compass correction, true heading of the vehicle must be computed by the magnetic heading from the compass. Magnetic heading is corrected for the Earth magnetic field declination (.beta..sub.d) and for mounting errors on the vehicle and residual hard/soft iron (ferrous material) errors. These mounting and ferrous material errors are estimated by DGPS/DR calibration, essentially by comparing the estimated true heading to the ground track angle computed from DGPS measurement data. A correction to the compass correction table (a lookup table indexed by magnetic heading) is computed based on this heading residual. The error in the table at the current magnetic heading is applied to the magnetic heading to form a corrected true heading.

CLAIMS:

4. The location determining system of claim 1, wherein said magnetic sensor assembly comprises a Hall effect sensor and a magnet, wherein said Hall effect sensor is fixed relative to a wheel of the respective golf cart and said magnet is coupled to said wheel for rotation about said Hall effect sensor as said wheel rotates during driving of said golf cart.

8. The location determining system of claim 4, wherein said magnet comprises a magnetic strip with multiple alternating magnetic poles thereon, and said magnetic strip is affixed to a wheel well of said wheel or mounting fixture thereof for passage of said alternating magnetic poles adjacent to said Hall effect sensor as

said wheel and said magnetic strip thereon rotates during driving of the respective golf cart about said golf course.

9. The location determining system of claim 8, wherein said Hall effect sensor is positioned to confront said magnetic strip in spaced-apart relation thereto to detect the number of alternating magnetic poles passing by said Hall effect sensor and the direction thereof as said magnetic strip rotates on said wheel during driving of said golf cart.

10. The location determining system of claim 9, wherein said Hall effect sensor is mounted on an axle of said golf cart on which said wheel rotates.

13. Apparatus for installation on a golf cart to calculate the distance from the cart to a golf cup, a hazard, or other feature of a hole of a golf course which has been surveyed so that the location of said golf cup, hazard, or other feature on said hole is known, to enable close approximation of the distance thereto from the lie of a golf ball proximate said cart, said golf cart having access to GPS transmissions solely for calibration of a dead reckoning (DR) navigation system installed on the cart, said apparatus comprising: a DR wheel sensor assembly for determining speed and direction of said cart relative to a known point of origin of said hole, said assembly including a magnetic strip having a plurality of alternating magnetic poles impressed longitudinally thereon for attachment to a cylindrical wall of a wheel or mounting fixture therefor of said golf cart, and a Hall effect sensor for detecting said alternating magnetic poles during rotation of said wheel when attached in a fixed location on said golf cart in confronting relation to said magnetic strip, to measure speed and forward-backward direction of the golf cart, and further including an electrically conductive housing for said sensor adapted for electrical insulation from the chassis of the golf cart, said housing connected to the sensor to share the same electrical ground therewith, so as to inhibit electrical and magnetic interference with operation of the sensor from the propulsion system of the golf cart or from other sources of electrical or magnetic field.

Previous Doc Next Doc Go to Doc#

L2: Entry 3 of 3 File: USPT Nov 14, 2000

DOCUMENT-IDENTIFIER: US 6148269 A
TITLE: Wheel diameter calibration system for vehicle slip/slide control

Abstract Text (1):
A method and apparatus for wheel diameter calibration in a vehicle of the type having a plurality of independently powered wheel-axle sets which can be implemented as a forced calibration while the vehicle is in either a tractive effort or an electrical braking mode. The process includes the steps of determining if vehicle tractive effort would be effected if one wheel-axle set were disabled and, if not, selectively disabling one of the wheel-axle sets, calculating vehicle speed from a present value of wheel diameter for the disabled axle and wheel revolutions per unit time, establishing a true value of vehicle speed from an independent measurement, computing the error between calculated vehicle speed and the true value of vehicle speed, and adjusting the present value of wheel diameter so as to minimize the computed speed error.

Brief Summary Text (4):
It is well known that maximum tractive or braking effort is obtained if each powered wheel of the vehicle is rotating at such an angular velocity that its actual peripheral speed is slightly higher (motoring) or slightly lower (braking) than the true vehicle speed (i.e., the linear speed at which the vehicle is traveling, usually referred to as "ground speed" or "track speed"). The difference between wheel speed and track speed is referred to as "slip speed." There is a relatively low limit value of slip speed at which peak tractive or braking effort is realized. This value, commonly known as maximum "creep speed," is a variable that depends on track speed and rail conditions. So long as the maximum creep speed is not exceeded, the vehicle will operate in a stable microslip or creep mode. If wheel-to-rail adhesion tends to be reduced or lost, some or all of the vehicle wheels may slip excessively, i.e., the actual slip speed may be greater than the maximum creep speed. Such a wheel slip condition, which is characterized in the motoring mode by one or more spinning axle-wheel sets and in the braking mode by one or more sliding or skidding axle-wheel sets, can cause accelerated wheel wear, rail damage, high mechanical stresses in the drive components of the propulsion system, and an undesirable decrease of tractive (or braking) effort.

Brief Summary Text (6):
In general, locomotive speed or tangential wheel speed can be calculated from measured motor rotor revolutions per minute ("RPM") values given the diameter of the associated wheel. Conventionally, a speed sensor or revolution counter is coupled to sense the rotational speed of an output shaft of each drive motor. The sensed speed is then converted to a value representative of wheel RPM by multiplying the sensed value in RPM by the gear ratio between the drive motor shaft and wheel/axle set. Tangential wheel speed is then calculated from wheel RPM. For example, a standard 42 inch locomotive wheel has a circumference C equal to .pi. times diameter D or 131.95 inches so that one wheel revolution advances the vehicle by 131.95 inches, assuming zero slip. From this it can be readily determined that a wheel RPM of 200 will produce a locomotive speed of about 25 MPH or, more precisely, about 24.9899 MPH. If the actual wheel diameter is 41.5 inches, the true

velocity can be calculated to be 24.6924 MPH which introduces an error of about 0.3 MPH. This speed difference represents an error which produces slip, since the control system regulates based on the assumed ideal diameter, and leads to a loss of tractive effort as well as creating additional wear on the wheels and rails. More importantly, if wheel calibration is in error, the control system will derate (reduce the available tractive or braking effort) when it is not necessary since the system will detect a speed error indicative of a wheel slip or slide.

Brief Summary Text (9):
The present invention is implemented in one form in which a wheel diameter calibration system for a traction vehicle having a plurality of independently powered wheel-axle sets, such as a locomotive, which system allows wheel diameter to be calibrated while the vehicle is in either a tractive effort or electrical braking mode of operation. In the illustrative system, calibration of each wheel-axle set is accomplished by systematically removing power from each wheel-axle set to place that wheel-axle set in a coast mode. The vehicle control initially determines whether a calibration is needed by comparing vehicle velocity as determined by an independent sensor, such as a radar or GPS sensor, to vehicle velocity as determined from a calculation of vehicle speed based upon wheel rotational speed and wheel diameter. If the velocities differ by more than some minimum value, a forced calibration mode is entered. In the forced calibration mode, the control determines first if vehicle tractive effort would be effected if one wheel-axle set were disabled. If not, the one wheel-axle set is disabled, with the commanded tractive effort being distributed over the remaining powered wheel-axle sets. The control thereafter integrates the velocity difference or error while continuously re-computing the error wherein the integrated error value becomes the value of wheel diameter. The control can interrupt the calibration process whenever the disabled wheel-axle set is needed to meet tractive effort requirements. During any interruption in calibration, the last computed value of wheel diameter is maintained so that future calibrations start from the last value thereby allowing calibration to be performed in discontinuous, piecemeal fashion. The control can also accelerate the integration process to perform faster calibration by varying the velocity error signal magnitude by multiplying the error signal by a selectable factor.

Detailed Description Text (2):
The present invention may be utilized in various types of alternating current (AC) induction motor powered vehicles such as, for example, transit cars and locomotives. For purpose of illustration, the invention is described herein as it may be applied to a locomotive. The propulsion system 10 of FIG. 1 includes a variable speed prime mover 11 mechanically coupled to a rotor of a dynamo electric machine 12 comprising a 3-phase alternating current (AC) synchronous generator or alternator. The 3-phase voltages developed by alternator 12 are applied to AC input terminals of a conventional power rectifier bridge 13. The direct current (DC) output of bridge 13 is coupled via DC link 14 to a plurality of controlled inverters 15A, 15B, 15C and 15D, each of which inverts the DC power to AC power at a selectable variable frequency. The AC power from each inverter is electrically coupled in energizing relationship to a corresponding one of a plurality of adjustable speed AC traction motors M1 through M4. Prime mover 11, alternator 12, rectifier bridge 13 and inverters 15A through 15D are mounted on a platform of the traction vehicle 10, illustrated as a 4-axle diesel-electric locomotive. The platform is in turn supported on two trucks 20 and 30, the first truck 20 having two axle-wheel sets 21 and 22 and the second truck 30 having two axle-wheel sets 31 and 32.

Detailed Description Text (3):
Each of the traction motors M1-M4 is hung on a separate axle and its rotor is mechanically coupled, via conventional gearing, in driving relationship to the associated axle-wheel set. In the illustrative embodiment, the two motors M1 and M2 are electrically coupled in parallel with one another and receive power from

inverters 15A, 15B while motors M3 and M4 are coupled to inverters 15C, 15D. Suitable current transducers 27 and voltage transducers 29 are used to provide a family of current and voltage feedback signals, respectively, representative of the magnitudes of current and voltage in the motor stators. Speed sensors 28 are used to provide RPM signals representative of the rotational speeds W1-W4 in revolutions per minute (RPM) of the motor shafts. These RPM signals are converted to wheel rotational speed from the known gear ratio of the mechanical coupling between the motor shaft and wheel axle. Wheel rotational speed is converted to vehicle linear speed based upon the assumed diameter of each driven wheel. For simplicity, only single lines have been indicated for power flow although it will be apparent that the motors M1-M4 are typically three phase motors so that each power line represents three lines in such applications.

CLAIMS:

1. A method for wheel diameter calibration in a vehicle of the type having a plurality of independently powered wheel-axle sets, the method comprising the steps of:

determining if vehicle tractive effort would be effected if one wheel-axle set were disabled and, if not, selectively disabling one of the wheel-axle sets;

calculating vehicle speed from a present value of wheel diameter for the disabled axle and wheel revolutions per unit time;

establishing a true value of vehicle speed from an independent measurement;

computing the error between calculated vehicle speed and the true value of vehicle speed; and

adjusting the present value of wheel diameter so as to minimize the computed speed error.

Previous Doc Next Doc Go to Doc#

L1: Entry 1 of 1 File: USPT Mar 2, 2004

US-PAT-NO: 6701228
DOCUMENT-IDENTIFIER: US 6701228 B2

TITLE: Method and system for compensating for wheel wear on a train

DATE-ISSUED: March 2, 2004

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Kane; Mark Edward	Orange Park	FL		
Shockley; James Francis	Orange Park	FL		
Hickenlooper; Harrison Thomas	Palatka	FL		

ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
Quantum Engineering, Inc.	Orange Park	FL			02

APPL-NO: 10/ 157874 [PALM]
DATE FILED: May 31, 2002

INT-CL: [07] G06 F 7/00

US-CL-ISSUED: 701/19; 701/200, 73/179R, 246/1C, 246/122R
US-CL-CURRENT: 701/19; 246/1C, 246/122R, 701/200, 73/178R

FIELD-OF-SEARCH: 701/19, 701/20, 701/200, 701/213, 73/178R, 246/1C, 246/122R, 246/167R, 246/182R, 246/473R

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

Search Selected Search ALL Clear

PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
4181943	January 1980	Mercer, Sr. et al.	
4208717	June 1980	Rush	701/20
4459668	July 1984	Inoue et al.	
4561057	December 1985	Haley, Jr. et al.	
4711418	December 1987	Aver, Jr. et al.	
5072900	December 1991	Malon	

☐				
☐	5129605	July 1992	Burns et al.	
☐	5177685	January 1993	Davis et al.	
☐	5332180	July 1994	Peterson et al.	
☐	5340062	August 1994	Heggestad	
☐	5364047	November 1994	Petit et al.	
☐	5394333	February 1995	Kao	
☐	5398894	March 1995	Pascoe	
☐	5452870	September 1995	Heggestad	
☐	5533695	July 1996	Heggestad et al.	
☐	5620155	April 1997	Michalek	
☐	5699986	December 1997	Welk	
☐	5740547	April 1998	Kull et al.	
☐	5751569	May 1998	Metel et al.	
☐	5791425	August 1998	Kamen et al.	180/7.1
☐	5794730	August 1998	Kamen	180/7.1
☐	5803411	September 1998	Ackerman et al.	
☐	5828979	October 1998	Polivka et al.	
☐	5867122	February 1999	Zahm et al.	
☐	5931882	August 1999	Fick et al.	701/50
☐	5944768	August 1999	Ito et al.	
☐	5947423	September 1999	Clifton et al.	246/62
☐	5950966	September 1999	Hungate et al.	
☐	5971091	October 1999	Kamen et al.	180/218
☐	5978718	November 1999	Kull	
☐	5995881	November 1999	Kull	
☐	6049745	April 2000	Douglas et al.	
☐	6081769	June 2000	Curtis	
☐	6102340	August 2000	Peek et al.	
☐	6135396	October 2000	Whitfield et al.	
☐	6179252	January 2001	Roop et al.	
☐	6218961	April 2001	Gross et al.	
☐	6220987	April 2001	Robichaux et al.	477/97
☐	6311109	October 2001	Hawthorne et al.	
☐	6322025	November 2001	Colbert et al.	
☐	6345233	February 2002	Erick	
☐	6360165	March 2002	Chowdhary	701/205
	6371416	April 2002	Hawthorne	

☐				
☐	6373403	April 2002	Korver et al.	
☐	6374184	April 2002	Zahm et al.	
☐	6377877	April 2002	Doner	
☐	6397147	May 2002	Whithead	
☐	6421587	July 2002	Diana et al.	
☐	6434466	August 2002	Robichaux et al.	701/54
☐	6456937	September 2002	Doner et al.	
☐	6459964	October 2002	Vu et al.	
☐	6459965	October 2002	Polivka et al.	
☐	6487478	November 2002	Azzaro et al.	

OTHER PUBLICATIONS

"Testimony of Jolene M. Molitoris, Federal Railroad Administrator, U.S. Department of Transportation before the House Committee on Transportation and Infrastructure Subcommittee on Railroads", Federal Railroad Administration, United States Department of Transportation, Apr. 1, 1998.
"System Architecture, ATCS Specification 100", May 1995.
"A New World for Communications & Signaling", Progressive Railroading, May 1986.
"Advanced Train Control Gain Momentum", Progressive Railroading, Mar. 1986.
"Railroads Take High Tech in Stride", Progressive Railroading, May 1985.
Lyle, Denise, "Positive Train Control on CSXT", Railway Fuel and Operating Officers Association, Annual Proceedings, 2000.
Lindsey, Ron A., "C B T M, Communications Based Train Management", Railway Fuel and Operating Officers Association, Annual Proceedings, 1999.
Moody, Howard G, "Advanced Train Control Systems A System to Manage Railroad Operations", Railway Fuel and Operating Officers Association, Annual Proceedings, 1993.
Ruegg, G.A., "Advanced Train Control Systems ATCS", Railway Fuel and Operating Officers Association, Annual Proceedings, 1986.
Malone, Frank, "The Gaps Start to Close"Progressive Railroading, May 1987.
"On the Threshold of ATCS", Progressive Railroading, Dec. 1987.
"CP Advances in Train Control", Progressive Railroading, Sep. 1987.
"Communications/Signaling: Vital for dramatic railroad advances", Progressive Railroading, May 1988.
"ATCS's System Engineer", Progressive Railroading, Jul. 1988.
"The Electronic Railroad Emerges", Progressive Railroading, May 1989.
"C.sup.3 Comes to the Railroads", Progressive Railroading, Sep. 1989.
"ATCS on Verge of Implementation", Progressive Railroading, Dec. 1989.
"ATCS Envolving on Railroads", Progressive Railroading, Dec. 1992.
"High Tech Advances Keep Railroads Rolling", Progressive Railroading, May 1994.
"FRA Promotes Technology to Avoid Train-To-Train Collisions", Progressive Railroading, Aug. 1994.
"ATCS Moving slowly but Steadily from Lab for Field", Progressive Railroading, Dec. 1994.
Judge, T., "Electronic Advances Keeping Railroads Rolling", Progressive Railroading, Jun. 1995.
"Electronic Advances Improve How Railroads Manage", Progressive Railroading, Dec. 1995.
Judge, T., "BNSF/UP PTS Pilot Advances in Northwest", Progressive Railroading, May 1996.
Foran, P., "Train Control Quandry, Is CBTC viable? Railroads, Suppliers Hope Pilot

Projects Provide Clues", Progressive Railroading, Jun. 1997.
"PTS Would've Prevented Silver Spring Crash: NTSB", Progressive Railroading, Jul. 1997.
Foran, P., "A `Positive` Answer to the Interoperability Call", Progressive Railroading, Sep. 1997.
Foran, P., "How Safe is Safe Enough?", Progressive Railroading, Oct. 1997.
Foran, P., "A Controlling Interest In Interoperability", Progressive Railroading, Apr. 1998.
Derocher, Robert J., "Transit Projects Setting Pace for Train Control", Progressive Railroading, Jun. 1998.
Kube, K., "Variations on a Theme", Progressive Railroading, Dec. 2001.
Kube, K., "Innovation in Inches", Progressive Railroading, Feb. 2002.
Vantuono, W., "New York Leads a Revolution", Railway Age, Sep. 1996.
Vantuono, W., "Do you know where your train is?", Railway Age, Feb. 1996.
Gallamore, R., "The Curtain Rises on the Next Generation", Railway Age, Jul. 1998.
Burke, J., "How R&D is Shaping the 21st Century Railroad", Railway Age, Aug. 1998.
Vantuono, W., "CBTC: A Maturing Technology", Third International Conference On Communications Based Train Control, Railway Age, Jun. 1999.
Sullivan, T., "PTC--Is FRA Pushing Too Hard?", Railway Age, Aug. 1999.
Sullivan, T., "PTC: A Maturing Technology", Railway Age, Apr. 2000.
Moore, W., "How CBTC Can Increase Capacity", Railway Age, Apr., 2001.
Vantuono, W., "CBTC: The Jury is Still Out", Railway Age, Jun. 2001.
Vantuono, W., "New-tech Train Control Takes Off", Railway Age, May 2002.
Union Switch & Signal Intermittent Cab Signal, Bulletin 53, 1998.
GE Harris Product Sheet: "Advanced Systems for Optimizing Rail Performance" and "Advanced Products for Optimizing train Performance", undated.
GE Harris Product Sheet: "Advanced, Satellite-Based Warning System Enhances Operating Safety", undated.
Furman, E., et al., "Keeping Track of RF", GPS World, Feb. 2001.
Walker, Publication No. US 2001/0056544 A1, Dec. 27, 2001.
Gazit et al., Publication No. US 2002/0070879 A1, Jun. 13, 2002.
Department of Transportation Federal Railroad Administration, Federal Register, vol. 66, No. 155, pp. 42352-42396, Aug. 10, 2001.

ART-UNIT: 3661

PRIMARY-EXAMINER: Cuchlinski, Jr.; William A

ASSISTANT-EXAMINER: Hernandez; Olga

ATTY-AGENT-FIRM: Piper Rudnick LLP Kelber; Steven B.

ABSTRACT:

A method and system for compensating for wheel wear uses position and/or speed information from an independent positioning system to measure some distance over which the train has traveled. Wheel rotation information is also collected over the distance. The wheel rotation information and distance and/or speed information are then used to determine the size of the train wheels. The method is performed periodically to correct for changes in wheel size over time due to wear so that the wheel rotation information can be used to determine train position and speed in the event of a positioning system failure.

60 Claims, 3 Drawing figures

Refine Search

Search Results -

Terms	Documents
L1 and gps	6

Database:

US Pre-Grant Publication Full-Text Database
US Patents Full-Text Database
US OCR Full-Text Database
EPO Abstracts Database
JPO Abstracts Database
Derwent World Patents Index
IBM Technical Disclosure Bulletins

Search: L4

Refine Search

Recall Text

Clear

Interrupt

Search History

DATE: Wednesday, May 18, 2005 Printable Copy Create Case

Set Name side by side	Query	Hit Count	Set Name result set
	DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR		
L4	L1 and gps	6	L4
L3	L2 AND (RPM$ OR TACHOMETER)	1	L3
L2	L1 and gps and distance and odometer	2	L2
L1	6148269.pn. or 6347265.pn. or 6446005.pn. or 6373403.pn. or 5796613.pn. or 6219609.pn.	6	L1

END OF SEARCH HISTORY

L4: Entry 5 of 6 File: USPT Nov 14, 2000

DOCUMENT-IDENTIFIER: US 6148269 A
TITLE: Wheel diameter calibration system for vehicle slip/slide control

Brief Summary Text (7):
The need for wheel diameter calibration has been recognized in the art. Typically, a locomotive is provided with an auxiliary ground speed sensor such as a radar unit (similar to the type used by police for monitoring automobile speed) or a satellite sensor (generally referred to as global position sensor or GPS). The ground speed signal from one of these sensors is compared to the speed determined from the motor shaft RPM sensor value and any error is corrected by adjusting the calculated value of wheel diameter. One problem with the prior art systems is that the comparison or calibration could only be performed when the locomotive was in a coast mode, i.e, the traction motors were not energized for either powering or braking of the locomotive. Further, it was generally necessary for the locomotive to be in such a coast mode for an extended, continuous time in order to complete the calibration. However, there are many instances in which the opportunity to operate a locomotive for an extended period in a coast mode is simply impractical. Accordingly, it would be advantageous to provide a wheel diameter calibration system which does not require coast mode operation and which does not require an extended, continuous time to achieve calibration.

Brief Summary Text (9):
The present invention is implemented in one form in which a wheel diameter calibration system for a traction vehicle having a plurality of independently powered wheel-axle sets, such as a locomotive, which system allows wheel diameter to be calibrated while the vehicle is in either a tractive effort or electrical braking mode of operation. In the illustrative system, calibration of each wheel-axle set is accomplished by systematically removing power from each wheel-axle set to place that wheel-axle set in a coast mode. The vehicle control initially determines whether a calibration is needed by comparing vehicle velocity as determined by an independent sensor, such as a radar or GPS sensor, to vehicle velocity as determined from a calculation of vehicle speed based upon wheel rotational speed and wheel diameter. If the velocities differ by more than some minimum value, a forced calibration mode is entered. In the forced calibration mode, the control determines first if vehicle tractive effort would be effected if one wheel-axle set were disabled. If not, the one wheel-axle set is disabled, with the commanded tractive effort being distributed over the remaining powered wheel-axle sets. The control thereafter integrates the velocity difference or error while continuously re-computing the error wherein the integrated error value becomes the value of wheel diameter. The control can interrupt the calibration process whenever the disabled wheel-axle set is needed to meet tractive effort requirements. During any interruption in calibration, the last computed value of wheel diameter is maintained so that future calibrations start from the last value thereby allowing calibration to be performed in discontinuous, piecemeal fashion. The control can also accelerate the integration process to perform faster calibration by varying the velocity error signal magnitude by multiplying the error signal by a selectable factor.

Detailed Description Text (7):
FIG. 2 is a simplified, functional block diagram of one form in which the present

invention can be implemented. The general concept is to provide a method for determining the actual diameter of a locomotive wheel even though the locomotive may be operating in a propulsion or electrical braking mode while calibration is occurring. The general concept further includes a method which allows the rate of calibration to be varied and be accomplished in a piecemeal manner. The calibration process uses two measured variables, axle speed (RPM) and true ground speed (tgss). Typically, the tgss signal is obtained from a conventional radar or GPS sensor, such as is shown at 37 in FIG. 1. Note that the control system of FIG. 2 is preferably implemented in software in the controller 26 although a hardware implementation is illustrated. Further, the system of FIG. 2 is associated with each wheel-axle set so that each can be calibrated.

Detailed Description Text (17):
A decision that an axle of the vehicle/locomotive needs calibration is determined from a persistence of differences between the calibration speed reference and the axle speed at low torque conditions. The system normally assumes that calibration is unnecessary. However, if the difference between the speed reference, e.g., the radar or GPS reference, and an axle speed signal is greater than a selected value, typically about one per cent, while the axle is operated at a relatively low tractive effort or horsepower (less than about 4500 lbs) and at a speed of more than a selected minimum such as about 5 MPH with all speed sensors operative, then calibration is desirable. Transient conditions are eliminated by requiring the above conditions to exist for some selected time interval such as 20 seconds. If calibration is needed, a NEED.sub.-- CAL flag (block 78) is set to allow a forced calibration to occur.

Previous Doc Next Doc Go to Doc#

L1: Entry 1 of 1 File: USPT Mar 2, 2004

US-PAT-NO: 6701228
DOCUMENT-IDENTIFIER: US 6701228 B2

TITLE: Method and system for compensating for wheel wear on a train

DATE-ISSUED: March 2, 2004

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Kane; Mark Edward	Orange Park	FL		
Shockley; James Francis	Orange Park	FL		
Hickenlooper; Harrison Thomas	Palatka	FL		

ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
Quantum Engineering, Inc.	Orange Park	FL			02

APPL-NO: 10/ 157874 [PALM]
DATE FILED: May 31, 2002

INT-CL: [07] G06 F 7/00

US-CL-ISSUED: 701/19; 701/200, 73/179R, 246/1C, 246/122R
US-CL-CURRENT: 701/19; 246/1C, 246/122R, 701/200, 73/178R

FIELD-OF-SEARCH: 701/19, 701/20, 701/200, 701/213, 73/178R, 246/1C, 246/122R, 246/167R, 246/182R, 246/473R

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

Search Selected Search ALL Clear

PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
4181943	January 1980	Mercer, Sr. et al.	
4208717	June 1980	Rush	701/20
4459668	July 1984	Inoue et al.	
4561057	December 1985	Haley, Jr. et al.	
4711418	December 1987	Aver, Jr. et al.	
5072900	December 1991	Malon	

☐				
☐	5129605	July 1992	Burns et al.	
☐	5177685	January 1993	Davis et al.	
☐	5332180	July 1994	Peterson et al.	
☐	5340062	August 1994	Heggestad	
☐	5364047	November 1994	Petit et al.	
☐	5394333	February 1995	Kao	
☐	5398894	March 1995	Pascoe	
☐	5452870	September 1995	Heggestad	
☐	5533695	July 1996	Heggestad et al.	
☐	5620155	April 1997	Michalek	
☐	5699986	December 1997	Welk	
☐	5740547	April 1998	Kull et al.	
☐	5751569	May 1998	Metel et al.	
☐	5791425	August 1998	Kamen et al.	180/7.1
☐	5794730	August 1998	Kamen	180/7.1
☐	5803411	September 1998	Ackerman et al.	
☐	5828979	October 1998	Polivka et al.	
☐	5867122	February 1999	Zahm et al.	
☐	5931882	August 1999	Fick et al.	701/50
☐	5944768	August 1999	Ito et al.	
☐	5947423	September 1999	Clifton et al.	246/62
☐	5950966	September 1999	Hungate et al.	
☐	5971091	October 1999	Kamen et al.	180/218
☐	5978718	November 1999	Kull	
☐	5995881	November 1999	Kull	
☐	6049745	April 2000	Douglas et al.	
☐	6081769	June 2000	Curtis	
☐	6102340	August 2000	Peek et al.	
☐	6135396	October 2000	Whitfield et al.	
☐	6179252	January 2001	Roop et al.	
☐	6218961	April 2001	Gross et al.	
☐	6220987	April 2001	Robichaux et al.	477/97
☐	6311109	October 2001	Hawthorne et al.	
☐	6322025	November 2001	Colbert et al.	
☐	6345233	February 2002	Erick	
☐	6360165	March 2002	Chowdhary	701/205
	6371416	April 2002	Hawthorne	

☐				
☐	6373403	April 2002	Korver et al.	
☐	6374184	April 2002	Zahm et al.	
☐	6377877	April 2002	Doner	
☐	6397147	May 2002	Whithead	
☐	6421587	July 2002	Diana et al.	
☐	6434466	August 2002	Robichaux et al.	701/54
☐	6456937	September 2002	Doner et al.	
☐	6459964	October 2002	Vu et al.	
☐	6459965	October 2002	Polivka et al.	
☐	6487478	November 2002	Azzaro et al.	

OTHER PUBLICATIONS

"Testimony of Jolene M. Molitoris, Federal Railroad Administrator, U.S. Department of Transportation before the House Committee on Transportation and Infrastructure Subcommittee on Railroads", Federal Railroad Administration, United States Department of Transportation, Apr. 1, 1998.
"System Architecture, ATCS Specification 100", May 1995.
"A New World for Communications & Signaling", Progressive Railroading, May 1986.
"Advanced Train Control Gain Momentum", Progressive Railroading, Mar. 1986.
"Railroads Take High Tech in Stride", Progressive Railroading, May 1985.
Lyle, Denise, "Positive Train Control on CSXT", Railway Fuel and Operating Officers Association, Annual Proceedings, 2000.
Lindsey, Ron A., "C B T M, Communications Based Train Management", Railway Fuel and Operating Officers Association, Annual Proceedings, 1999.
Moody, Howard G, "Advanced Train Control Systems A System to Manage Railroad Operations", Railway Fuel and Operating Officers Association, Annual Proceedings, 1993.
Ruegg, G.A., "Advanced Train Control Systems ATCS", Railway Fuel and Operating Officers Association, Annual Proceedings, 1986.
Malone, Frank, "The Gaps Start to Close"Progressive Railroading, May 1987.
"On the Threshold of ATCS", Progressive Railroading, Dec. 1987.
"CP Advances in Train Control", Progressive Railroading, Sep. 1987.
"Communications/Signaling: Vital for dramatic railroad advances", Progressive Railroading, May 1988.
"ATCS's System Engineer", Progressive Railroading, Jul. 1988.
"The Electronic Railroad Emerges", Progressive Railroading, May 1989.
"C.sup.3 Comes to the Railroads", Progressive Railroading, Sep. 1989.
"ATCS on Verge of Implementation", Progressive Railroading, Dec. 1989.
"ATCS Envolving on Railroads", Progressive Railroading, Dec. 1992.
"High Tech Advances Keep Railroads Rolling", Progressive Railroading, May 1994.
"FRA Promotes Technology to Avoid Train-To-Train Collisions", Progressive Railroading, Aug. 1994.
"ATCS Moving slowly but Steadily from Lab for Field", Progressive Railroading, Dec. 1994.
Judge, T., "Electronic Advances Keeping Railroads Rolling", Progressive Railroading, Jun. 1995.
"Electronic Advances Improve How Railroads Manage", Progressive Railroading, Dec. 1995.
Judge, T., "BNSF/UP PTS Pilot Advances in Northwest", Progressive Railroading, May 1996.
Foran, P., "Train Control Quandry, Is CBTC viable? Railroads, Suppliers Hope Pilot

Projects Provide Clues", Progressive Railroading, Jun. 1997.
"PTS Would've Prevented Silver Spring Crash: NTSB", Progressive Railroading, Jul. 1997.
Foran, P., "A `Positive` Answer to the Interoperability Call", Progressive Railroading, Sep. 1997.
Foran, P., "How Safe is Safe Enough?", Progressive Railroading, Oct. 1997.
Foran, P., "A Controlling Interest In Interoperability", Progressive Railroading, Apr. 1998.
Derocher, Robert J., "Transit Projects Setting Pace for Train Control", Progressive Railroading, Jun. 1998.
Kube, K., "Variations on a Theme", Progressive Railroading, Dec. 2001.
Kube, K., "Innovation in Inches", Progressive Railroading, Feb. 2002.
Vantuono, W., "New York Leads a Revolution", Railway Age, Sep. 1996.
Vantuono, W., "Do you know where your train is?", Railway Age, Feb. 1996.
Gallamore, R., "The Curtain Rises on the Next Generation", Railway Age, Jul. 1998.
Burke, J., "How R&D is Shaping the 21st Century Railroad", Railway Age, Aug. 1998.
Vantuono, W., "CBTC: A Maturing Technology", Third International Conference On Communications Based Train Control, Railway Age, Jun. 1999.
Sullivan, T., "PTC--Is FRA Pushing Too Hard?", Railway Age, Aug. 1999.
Sullivan, T., "PTC: A Maturing Technology", Railway Age, Apr. 2000.
Moore, W., "How CBTC Can Increase Capacity", Railway Age, Apr., 2001.
Vantuono, W., "CBTC: The Jury is Still Out", Railway Age, Jun. 2001.
Vantuono, W., "New-tech Train Control Takes Off", Railway Age, May 2002.
Union Switch & Signal Intermittent Cab Signal, Bulletin 53, 1998.
GE Harris Product Sheet: "Advanced Systems for Optimizing Rail Performance" and "Advanced Products for Optimizing train Performance", undated.
GE Harris Product Sheet: "Advanced, Satellite-Based Warning System Enhances Operating Safety", undated.
Furman, E., et al., "Keeping Track of RF", GPS World, Feb. 2001.
Walker, Publication No. US 2001/0056544 A1, Dec. 27, 2001.
Gazit et al., Publication No. US 2002/0070879 A1, Jun. 13, 2002.
Department of Transportation Federal Railroad Administration, Federal Register, vol. 66, No. 155, pp. 42352-42396, Aug. 10, 2001.

ART-UNIT: 3661

PRIMARY-EXAMINER: Cuchlinski, Jr.; William A

ASSISTANT-EXAMINER: Hernandez; Olga

ATTY-AGENT-FIRM: Piper Rudnick LLP Kelber; Steven B.

ABSTRACT:

A method and system for compensating for wheel wear uses position and/or speed information from an independent positioning system to measure some distance over which the train has traveled. Wheel rotation information is also collected over the distance. The wheel rotation information and distance and/or speed information are then used to determine the size of the train wheels. The method is performed periodically to correct for changes in wheel size over time due to wear so that the wheel rotation information can be used to determine train position and speed in the event of a positioning system failure.

60 Claims, 3 Drawing figures

Previous Doc Next Doc Go to Doc#